

Research on the Design and Implementation of a Multi-scene Web-based Video Conferencing and Live Streaming System for Colleges and Universities

Xiuru Jian^{1,*}, Yanjiao Wei², Ziyue Liu¹, Ruilong Bai¹

¹Beijing Polytechnic, Beijing, China

²Beijing University of Posts and Telecommunications, Beijing, China

*Corresponding author: jzm7897@163.com

Abstract: With the increasing popularity of distance education and online learning in colleges and universities, the network video conference and live streaming system with multiple scenes has become an important part of the information construction of college education. In this paper, for the problems of the current network video conference and live streaming system in colleges and universities, we design and implement a network video conference and live streaming system supporting multiple scenarios. The system adopts the audio and video transmission scheme based on WebRTC technology, supports multiple platforms such as Web, Android and iOS, and integrates a variety of functional modules, including screen sharing, interactive Q&A, voting, recording and playback, etc. The experimental results show that the system is stable and efficient, and it can meet the demand for web video conferencing and live streaming in multiple scenarios in universities.

Keywords: Web video conferencing; Live streaming system; WebRTC; Multi-scene; Education informatization

1. Introduction

With the continuous development and popularity of Internet technology, distance education and online learning in colleges and universities have become an important trend of education informatization. In this context, network video conference and live streaming system, as an efficient and convenient education informatization tool, it has been paid attention to and adopted by more and more colleges and universities. However, there are still many problems in most of the current university network video conferencing and live streaming systems, such as not supporting multiple scenes, instability and single function, which cannot meet the diversified educational needs. Therefore, this paper aims to design and implement a network video conferencing and live streaming system that supports multiple scenarios, so as to satisfy the needs of university education informatization [1].

2. Problems of Web-based Videoconferencing and Live Streaming Systems in Colleges and Universities

2.1. Unstable System Availability

Unstable system availability refers to unpredictable failures in the use of web-based video conferencing and live streaming systems, such as network disconnection, video lag, and sound distortion. These problems may be caused by insufficient network bandwidth, inadequate equipment configuration, incompatible software versions, etc. Due to the frequent use of university network video conferencing and live streaming systems, unstable system availability can adversely affect the teaching and research activities of the university. On the one hand, when the network video conferencing and live streaming system fails at critical moments, such as important meetings and seminars, it can adversely affect the teaching and research activities of the school, and even lead to the damage of the school's reputation. On the other hand, the learning and working experience of students and teachers will be affected, which will lead to a decrease in the trust of students and teachers in the web-based video conferencing and live streaming system, and thus reduce its usage.

2.2. Insufficient Network Bandwidth

Insufficient network bandwidth is one of the more common problems in college network video conferencing and live streaming systems. When multiple users use the system at the same time, the network bandwidth is easily occupied, resulting in video picture and audio lag and delay, which brings great inconvenience to the user's experience. At the same time, insufficient bandwidth can also lead to a decrease in video resolution and clarity, which affects the effect and quality of video conferencing and live streaming. The main reasons for insufficient network bandwidth are as follows: First, the bottleneck problem of network bandwidth in colleges and universities. The bottleneck problem of network bandwidth in colleges and universities refers to the network video conference and live streaming system in colleges and universities. Due to the small network bandwidth, it is unable to meet the demand of multiple users using the system at the same time, which leads to problems such as video quality degradation and screen lag. This is because in video conferencing and live streaming systems, video streams need to be transmitted through the network, taking up a large amount of network bandwidth resources [2]. The network bandwidth of many universities has bottleneck problems, mainly manifested as slow network transmission speed, which cannot support multiple users to use the system at the same time, leading to video quality degradation and affecting users' using experience. Especially during peak periods, such as exams, commencement ceremonies, graduation ceremonies and other events, the network bandwidth is easily occupied, which leads to the stability of the system being affected. Secondly, the system design and configuration are unreasonable. The design and configuration of some colleges and universities network video conference and live broadcast systems are not scientific and reasonable enough, which leads to the waste of network resources and unnecessary bandwidth occupation. Third, the network environment and equipment are unstable. The instability of network environment and equipment is also one of the important reasons for the lack of network bandwidth in colleges and universities. When using network video conference and live streaming system, users' devices and network environment may have various faults, such as device driver problems, software compatibility problems, network delay problems, etc. These problems will affect users' network experience and consume network bandwidth resources at the same time. For example, when using the live video streaming function, if the user's device performance is insufficient or the network environment is unstable, it will lead to problems such as video screen lag and unclear sound, thus affecting the user's viewing experience. In addition, an unstable network environment can also lead to fluctuations in network bandwidth, and when the network environment is poor, the network bandwidth is easily reduced, thus leading to a lack of bandwidth [3].

2.3. School Security Issues

Network video conferencing and live streaming systems face various security threats and risks in the process of use. First, hacking is one of the most common security threats. Hackers may take advantage of system vulnerabilities or weak passwords, etc., so as to invade the system to obtain sensitive information or manipulate the system. Second, network viruses and malware may also pose risks to the system. These viruses and software can spread through emails, downloads and shared files, causing system breakdown or information leakage. In addition, unauthorized access, data loss or leakage are also common security issues. If an unauthorized user accesses the system, this can compromise important information or manipulate the system. Data loss or leakage, which may result in the leakage or loss of important data of the university in teaching, research and management, which may bring great losses to the university.

2.4. Inadequate Staffing

Inadequate staffing is another problem facing university web-based video conferencing and live streaming systems. Since these systems require technical maintenance and management, they need to be supported and maintained by professional technicians. However, some universities have insufficient staffing in this area to solve system problems in a timely manner, which affects the stability and availability of the system. Specifically, inadequate staffing may lead to the following problems: First, system failures are not repaired in time. When the system fails, if there are not enough technicians to maintain it, the system may be in a state of failure for a long time, which affects the user's experience and teaching effect. Second, the system upgrade and update is not timely. With the continuous development of technology, network video conferencing and live streaming systems also need to be constantly updated and upgraded, so as to satisfy the needs and security requirements of users. However, if there are not enough technical staff to upgrade and update the system, the system may lag

behind the technical development and affect the user experience and security. Third, system security problems are not solved in a timely manner. With the increasing number of network attacks, the security of web video conferencing and live streaming systems is becoming more and more important. Without sufficient technical staff for system security management and vulnerability repair, the system may face the risk of being attacked or leaking important information [4].

2.5. Compatibility Issues

Compatibility issues are another factor that affects the usability of college web video conferencing and live streaming systems. Since different browsers and operating systems have their own characteristics and different technical support, developers need to adapt and optimize for different platforms, so as to ensure the compatibility of the system. If a system can only run on a specific browser or operating system, it will limit the scope of users' usage and reduce the usability of the system. Especially in a university environment, users may have a variety of browser and operating system types. If the system is not compatible with these different environments, it will cause inconvenience to users, and it may even make it impossible to use properly.

3. Solutions to the Problems of Web-based Videoconferencing and Live Streaming Systems in Colleges and Universities

3.1. To improve the Availability and Stability of the System, the Following Measures can be Taken

Hardware upgrade and optimization: To address the bottleneck of hardware devices, servers, routers and other devices can be upgraded and optimized, so as to improve the performance and stability of the system [5]. Optimization of system software: Optimization of system software includes simplifying the operation process of the system, optimizing the network communication, and improving the reliability and security of the software as shown in Figure 1. Optimization of database management: Optimization and management of the database, including backup and recovery of the database, cleaning and sorting of data, optimization of index and table structure, etc., so as to improve the availability and stability of the database. In order to improve the availability stability of the system, we can take system monitoring and troubleshooting measures. Specifically, the following methods can be used. Establishing a system monitoring platform: By establishing a system monitoring platform, the system indicators can be monitored in real time, and abnormal system problems can be found and solved in a timely manner. The monitoring platform can include system log monitoring, server performance monitoring, network bandwidth monitoring, etc. Implementing fault self-healing: Based on the system monitoring platform, the availability stability of the system can be improved by implementing fault self-healing. For example, set automatic fault transfer to automatically transfer user requests to other available servers when one server fails to ensure service continuity. Introduce machine learning and artificial intelligence technologies: Machine learning and artificial intelligence technologies can analyze massive amounts of data, which can help the system automatically diagnose faults and repair them, so as to improve the stability and availability of the system. For example, by analyzing historical data through machine learning technology, it is possible to predict the types of faults that may occur in the system, and take measures to prevent and repair them in advance. Establishing fault response mechanism: On the basis of system monitoring and fault diagnosis, it is also necessary to establish a perfect fault response mechanism to timely respond to users' feedback and reported problems, and to effectively solve them. In addition, the sea can establish a professional operation and maintenance team, so as to provide professional technical support and services for the system. User training and technical support: Training and technical support are provided to system users, which can improve their technical level and ability to cope with problems, and reduce system failures caused by human factors. Through the implementation of the above measures, the availability and stability of the system can be improved, which provides strong support for the smooth operation of the university network video conference and live broadcast system.

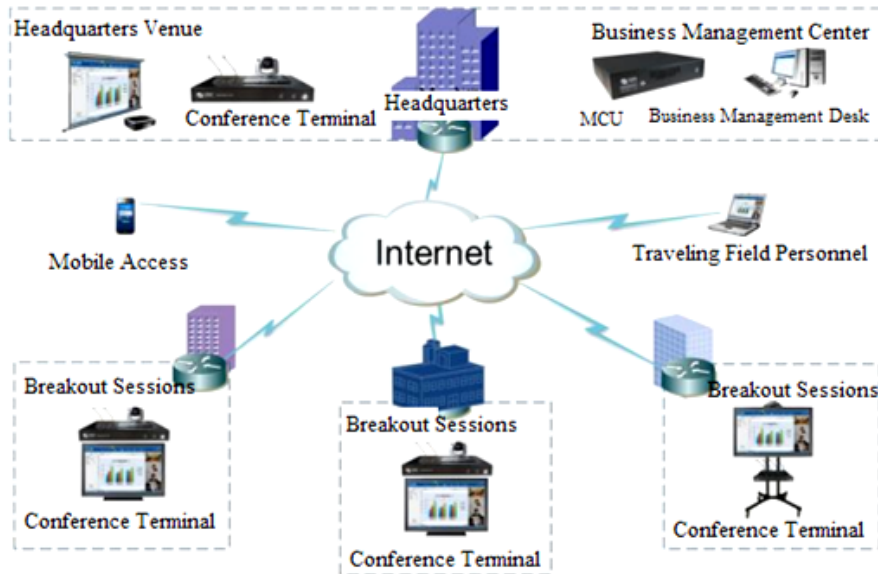


Figure 1: Video conference system.

3.2. Increase Network Bandwidth

We can solve the problem of insufficient network bandwidth by purchasing higher speed network bandwidth, which can increase the number of users watching videos online at the same time, thus improving the availability and stability of the system. Compress the video: By compressing the video, the bandwidth occupied during video transmission can be reduced, thus reducing the pressure on the network bandwidth. With the premise of ensuring video quality, the video compression technology can improve the efficiency of video transmission. Using CDN technology: By using CDN technology, the video content is distributed to different servers and the video stream is directed to the server at the user's location for transmission, which can effectively reduce the bandwidth consumption, and improve the transmission speed and quality of the video as shown in Figure 2. Optimize network structure: The lack of network bandwidth, which also may be related to the network equipment and technical level of colleges and universities. Some colleges and universities may not update network equipment in time or adopt advanced network technology, so they cannot make full use of network bandwidth resources. In addition, some colleges and universities may also not formulate reasonable network usage policies and management measures, resulting in unreasonable occupation of network bandwidth resources, which may also lead to the problem of insufficient network bandwidth [6]. Insufficient network bandwidth is an important problem faced by university network video conference and live streaming system, which needs to be optimized and improved from several aspects, so as to improve the availability and stability of the system. Limit the number of simultaneous online users: For some colleges and universities with limited network bandwidth, they can adopt the way of limiting the number of simultaneous online users, so as to avoid the situation that the network bandwidth is occupied. By setting the maximum number of people online, which can effectively ensure the quality and stability of the video.

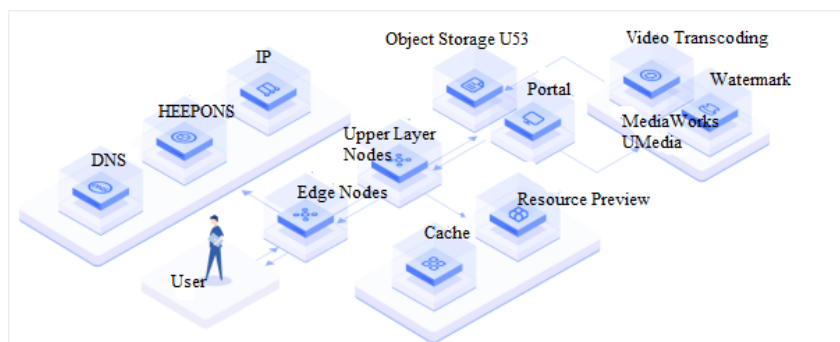


Figure 2: CDN technology framework.

3.3. Perfect System Security Management Mechanism

Perfect system security management mechanism, which is one of the important means to solve the security problem of university network video conference and live broadcast system. Specifically, we can take the following measures. Set authority control: according to the identity and authority of users, the functions in the system are restricted and authorized. For some important operations, we can set up multiple verification and approval mechanisms, so as to ensure the legitimacy and security of the operation. Log audit: record the operations and events in the system, and timely find and solve security problems, which can encrypt key information to prevent data leakage. Vulnerability scanning: Regular vulnerability scanning of the system, and timely detection and resolution of vulnerabilities, so as to improve the security and stability of the system. Encryption of data transmission and storage of the system, which can effectively safeguard user data, we can also use SSL/TLS protocol to encrypt data transmission, so as to prevent man-in-the-middle attacks and data leakage. For users' personal information and sensitive data, we can use AES, RSA and other encryption algorithms for encryption processing, so as to ensure that the data is protected during transmission and storage. In addition, we can also use data backup and disaster recovery mechanisms, thus ensuring that system data is effectively backed up and restored, then reducing the risk of data loss. Log auditing refers to recording, keeping and reviewing the operation logs in the system, so as to facilitate the tracing and analysis of the operation in the system. For college network video conference and live broadcast system, log audit can help administrators understand the usage of the system, discover abnormal behaviors and security loopholes in the system in time, and take corresponding measures to repair and strengthen. In terms of log auditing, the university network video conference and live streaming system needs to establish a perfect log recording mechanism, then record the operation behavior of users and the operation of the system, and save the logs in a safe and reliable storage medium. In addition, the administrator also needs to review the logs regularly, then look for abnormal behaviors and security events in the system, and take corresponding measures to deal with them in time. Vulnerability scanning refers to the use of automated tools to scan and detect possible vulnerabilities in the system, so as to find and timely repair the security vulnerabilities in the system. For university network video conferencing and live streaming system, vulnerability scanning can help system administrators discover the vulnerabilities existing in the system, and then fix them in time, so as to prevent hackers from using these vulnerabilities to attack and damage the system. Vulnerability scanning can be done using automated vulnerability scanning tools such as OpenVAS, Nessus, etc. These tools can scan for vulnerabilities in the system and generate detailed vulnerability reports. Meanwhile, system administrators can also perform manual vulnerability scans, by simulating a hacking attack to discover the vulnerabilities that exist in the system [7].

3.4. Strengthen the Training and Cultivation of Technical Personnel

Strengthening the training and cultivation of technical personnel, which is an important measure to solve the shortage of staffing of network video conference and live broadcast system in colleges and universities. Specifically, it includes the following aspects: strengthen the training of technical personnel. For technicians of different levels and functions, carry out systematic technical training and professional capacity enhancement courses, so as to improve their technical level and problem-solving ability. At the same time, provide more practical opportunities for technicians to enhance their experience and skills. Establish a sound technical team. Organize technical staff into a team to work collaboratively and support each other. Establish a technical knowledge base, summarize and classify common system problems, and form a standardized process for problem solving. Actively introduce talents. Increase the efforts to introduce technical talents while ensuring the quality of personnel. Introduce talents with relevant experience and technical ability, and then accelerate the construction of technical staff. Strengthen personnel management. Establish a standardized personnel management system, including the division of responsibilities, assessment and evaluation, and incentive mechanisms. Encourage technical personnel to take the initiative to learn and explore new technologies, and continuously improve comprehensive quality and professional skills. Strengthen the training and cultivation of technical personnel, which is an important measure to solve the shortage of staffing of network video conference and live broadcast system in colleges and universities. Meanwhile, the training of technicians is strengthened. For technicians of different levels and functions, we carry out systematic technical training and professional ability enhancement courses, so as to improve their technical level and problem-solving ability. At the same time, provide more practical opportunities for technicians, enhancing establish a sound technical team. Organize technical staff into a team to work collaboratively and support each other. Establish a technical knowledge base, summarize and classify common system problems, and form a standardized process for problem solving. Actively introduce

talents. Increase the efforts to introduce technical talents under the premise of ensuring the quality of personnel. Introduce talents with relevant experience and technical ability, and accelerate the construction of the technical staff. Strengthen personnel management. Establish a standardized personnel management system, including the division of responsibilities, assessment and evaluation, and incentive mechanism. Encourage technical personnel to take the initiative to learn and explore new technologies and continuously improve their comprehensive quality and professional skills.

3.5. Adopting Cross-platform Technology

Adopting cross-platform technology is an effective measure to improve system compatibility. HTML5 is a cross-platform technology, which provides rich tags and APIs that can run on different browsers and devices. Using HTML can make the system's interface more user-friendly and feature-rich. At the same time, HTML5 also supports video and audio playback functions, which can enable web video conferencing and live streaming functions. WebRTC is an open source, cross-platform technology that can run on different browsers and operating systems. WebRTC supports audio and video communication, including peer-to-peer communication and multi-person communication. Using WebRTC technology, which allows for better compatibility and usability of web video conferencing and live streaming systems, and users can use the system on different devices and browsers, increasing the user coverage and usage of the system. In addition to using cross-platform technology, the compatibility of the system can also be improved through testing and optimization. Comprehensive testing of the system, including testing on different browsers and operating systems, identifies and resolves compatibility issues. At the same time, we have to optimize the system, so as to reduce the dependence on specific browsers or operating systems, and improve the compatibility and usability of the system. Technical specification is an effective way to solve the compatibility problem of university network video conference and live streaming system. By formulating a unified technical specification, the development and maintenance process of the system can be standardized, the tasks and responsibilities of developers can be clarified, and the quality and stability of the system can be improved. The technical specification should include the following contents. Browser compatibility specification: specify which mainstream browsers the system can run on and the browser version requirements. Operating system compatibility specification: specify which operating systems the system can run on, and the requirements of the operating system version. Front-end framework specification: specify the front-end framework and related technologies used by the system, such as React, Angular, Vue, etc. Back-end technology specification: specify the back-end technology and related technologies used by the system, such as Java, Python, PHP, etc. Database specification: specify the database type and version adopted by the system, as well as the database design and management specification. By formulating a unified technical specification, the stability and compatibility of the system running on different browsers and operating systems can be guaranteed, thus improving the usability and user experience of the system [8]. At the same time, the development of technical specifications can also improve the technical level and quality of developers, promoting the development and progress of technology. Multi-terminal adaptation: for different resolutions and different devices, you can realize multi-terminal adaptation through adaptive layout, responsive design and other technologies to improve the user experience. User feedback mechanism: establish a user feedback mechanism, then collect user feedback problems and needs in a timely manner, optimize and improve them in a targeted manner, and improve system compatibility and user satisfaction. Testing and verification: In the process of system development and update, adequate testing and verification should be conducted, so as to ensure the stability and compatibility of the system running on various platforms and terminals, and to avoid compatibility problems.

4. Conclusion

Network video conferencing and live streaming systems in colleges and universities, which are important tools indispensable for teaching, research and management in colleges and universities at present. However, these systems face many problems in the process of use, such as insufficient bandwidth, security problems, insufficient compatibility and insufficient staffing, etc. These problems seriously affect the stability and availability of the system, which also affect the user experience. Therefore, universities need to take effective measures to gradually solve these problems from the aspects of technology, management and training, so as to improve the efficiency and quality of network video conference and live streaming system, and finally provide better support for teaching, research and management of universities.

Acknowledgements

Beijing Polytechnic General Project of Science and Technology, Project Number: 2023x011-Kxy.

References

- [1] Li Kong. *Informatization Teaching Design of Basic Accounting under the Environment of Education Informatization*[C]//Institute of Management Science and Industrial Engineering. *Proceedings of 2019 5th International Workshop on Education, Development and Social Sciences (IWEDSS 2019)*. Francis Academic Press, 2019:736-738.
- [2] Tian L. *Exploring the Design and Application Problems of Micro-courses in Chinese Teaching under the Background of Education Informatization*[C]//Singapore Management and Sports Science Institute,Singapore,Information Engineering Research Institute,USA.*Proceedings of 2019 7th ICASS International Conference on Education Innovation,Sport Science and Health(EISSH 2019)(Education Innovation,Sport Science and Health, VOL. 136)*.2019:174-178.
- [3] Dading Z. *Exploration and Research of Physical Education Informatization in Colleges and Universities in Mobile Internet Era*[C]//Institute of Management Science and Industrial Engineering. *Proceedings of 2019 3rd International Conference on Education Technology and Economic Management (ICETEM 2019)*. Francis Academic Press, 2019:334-338.
- [4] Liu N. *Research on the Effective Construction of Ecological Classroom of College English under the Background of Education Informatization* [C]//Institute of Management Science and Industrial Engineering. *Proceedings of 2019 9th International Conference on Social Science and Education Research(SSER 2019)*.Francis Academic Press, 2019:1616-1620.
- [5] Wang Qingsong. *Research on Online Education Informatization of Cadres from the Perspective of Management* [J]. *Journal of Political Science Research*, 2022:156-159.
- [6] Svetlana A. Bazhenova, Баженова Светлана Анатольевна. *Approaches to improving the training of teachers working under the International Baccalaureate programs in the field of education informatization* [J]. *RUDN Journal of Informatization in Education*, 2020: 213-216.
- [7] Torrato Janette Biales, Aguja Socorro Echevarria, Prudente Maricar Sison. *Using Web Video Conferencing to Conduct a Program as a Proposed Model toward Teacher Leadership and Academic Vitality in the Philippines* [J]. *Education Sciences*, 2021: 89-94.
- [8] McCay Shelby D., Lopez Roel R., Sansom April C., Farrell Christina M., Holmes Jared M., Lopez Angelica, Cathey James C. *Use of live streaming systems in field-based learning* [J]. *Wildlife Society Bulletin*, 2022: 47-53.